PATENT SPECIFICATION 1 536 278

1 536 278

(21) Application No. 55185/74 (22) Filed 20 Dec. 1974 (19)

(23) Complete Specification filed 17 March 1976

(44) Complete Specification published 20 Dec. 1978

(51) INT. CL.² G03B 21/00

(52) Index at acceptance
G2J 41AX 41C2 41H 41K
G5G 5Y

(72) Inventor REGINALD FREDERICK HANSFORD

# (54) IMPROVEMENTS IN OR RELATING TO PROJECTORS

(71) We, DECCA LIMITED, a British Company, of Decca House, 9 Albert Embankment, London, SE1 7SW, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a projector for projecting a movable spot of light onto a screen, and is particularly, but not exclusively, applicable to navigational training apparatus in which one or more moving spots of light are projected onto a screen to simulate a changing pattern of nagivation lights.

These lights may, for instance be such as would, in a true situation, be observed from the bridge of a ship proceeding along a buoyed channel.

The pattern of lights along a buoyed channel as seen by the navigator of a ship proceeding along the channel is similar to the pattern of street lamps seen by a motorist driving along a lighted street, except that the buoy-lights are below eye-level rather than above. The distant lights appear to move very slowly, while the apparent motion of near lights increases rapidly as they pass out of the driver's field of view on either his left or his right side. The form of the changing picture that should be presented on a screen, in front of an observer, in order to simulate the changing navigational situation, corresponds to the pattern that he would actually see if he were standing on the ship's bridge (at a particular height above the water) at a particular, but alterable, point in the channel .

It will be apparent that the pattern of lights may comprise not only buoy lights, but also the lights of other vessels, shore lights, lighthouse beacons, etc. The term navigation light used hereinafter is intended to cover all of these forms of lights.

A particular characteristic of buoy light (as opposed to a *ship's* navigation light) is that it does not show continuously but shows only for, say, 1 second in every 10 seconds. Alternatively, it may be showing for most of the time but be extinguished for, say, 1 second in every 10 seconds. A buoy operating in the former manner is known as a "flashing" buoy, and a buoy operating in the latter manner is known as an "occulting" buoy.

Some buoys show a white light, others show a red, some green, and a lighthouse may show a sequence of flashes using two or more colours. (For simplicity of description "white" is deemed to be a colour.) It would be advantageous therefore, that each light spot projected onto the screen be controllable so that it can appear intermittently and in either of two or more colours.

According to the invention there is provided a projector for projecting a movable spot of light onto a screen comprising an optical system including means defining an aperture which is controllably displaceable in a predetermined aperture plane, a light source for illuminating the aperture and means for focusing an image of the illuminated aperture onto the screen to form a spot of light thereon, said means defining the displaceable aperture comprising a first movable element defining a straight slot which is transparent to light from said light source, a second movable element which defines a straight slot which is also transparent to light from said light source and which crosses the slot of the first element at a crossing point defining said aperture, and means for independently moving said first and second elements to displace the aperture in said aperture plane.

The first and second elements may comprise a pair of plates, each of which is opaque apart from a fine straight transparent line which constitutes the slot, the said plates being mounted adjacent and parallel to one another with the crossed lines preferably, but not necessarily orthogonal, and each being arranged to be displaced in a direction preferably perpendicular to its own line.

*Means may be provided for interrupting* the optical path of light from the aperture, thereby enabling the intermittent projection of the spot, and/or for interposing a coloured filter into the optical path, thereby to change the colour of the spot. This means may comprise a movable shutter between the elements and a projection lens driven by a stepper motor to any one of several, for instance three positions. In one of these positions, the light is cut off, in another the light is unchanged and in the third a coloured, for instance red, filter is interposed. Alternatively, a number of shutter/filter blades may be provided, each movable into the optical path to colour or to block the light beam from the aperture.

The invention also relates to a simulating system including a screen, and a plurality of projectors as hereinbefore defined, arranged to project light spots onto the screen, the first and second elements of the projectors being displaceable to produce a changing pattern of lights on the screen.

The means for moving the first and second elements may comprise a lead screw and motor arrangement, the operation of the motor being controlled from a computer, in accord with information concerning the relative positions of the lights, thereby to simulate a pattern of navigation lights.

The screen may be opaque, in which case the light pattern would be visible only on the same side of the screen as the projection apparatuses, or translucent, in which case the pattern could be viewed from either side.

An embodiment of the invention will now be described by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a schematic diagram illustrating a navigation light siimulating system including a plurality of projection apparatuses in accordance with the invention;

Figure 2 is another schematic diagram illustrating the optical arrangement of each of the projection apparatuses in the system of Figure 1;

Figure 3 is a schematic diagram illustrating the arrangement of a pair of movable elements of a projector according to the invention, and one means for driving these elements;

Figure 4 is a schematic diagram similar to Figure 3, illustrating another means for driving the movable elements;

Figure 5 is a vertical section illustrating the form and manner of mounting of these movable elements on a vertically disposed mounting plate in one preferred embodiment of the invention;

Figure 6 is an elevational view of the arrangement of Figure 5, as seen from side 6 and shows a number of further features of the preferred embodiment;

*Figure 7 is an elevational view of the arrangement* of Figure 5, as seen from side 7, and also shows further features of the preferred embodiment;

Figure 8 shows one arrangement of shutter and filter elements which may be used in a projector according to the invention, and

Figure 9 shows an alternative shutter and filter element arrangement.

Like parts are designated by the same reference numerals in the different figures of the accompanying drawings.

With reference first to Figure 1, a navigation light simulating system 1 includes a screen 2 and a plurality of light spot projectors 3 arranged to project spots of light, one from each projector onto the screen. The projectors are constructed so as to permit movement of the light spots, as will be described with reference to Figures 2 to 7.

The movement of the spots is controlled by a digital computer 4 which has a plurality of output channels 5 each coupled to the corresponding projector through a digital to analogue converter 6. Alternatively, a number of analogue computers could be used.

For the construction of the projectors, reference is now made to Figures 2 to 7. The optical arrangement, illustrated schematically in Figure 2 is similar to that used in a simple slide projector, there being provided an incandescent or gas discharge lamp 7, a concave mirror 8, a triple condenser lens system comprising converging lenses 9, 10 and 11, a heat filter 12 and a projection lens system 13. In place of the usual slide frame, there is provided a spot forming and moving device comprising a pair of closely spaced parallel plates 14 and 15 mounted normally to the optical axis 16 of the projector. Each of these plates is opaque except for a fine transparent line. The line on the plate 14 is horizontal, and the line on the plate 15 is vertical. The plates are movable in orthogonal directions, each being movable in a direction perpendicular to that of its transparent line. That is to say, as seen in Figure 2, plate 14 is movable vertically, while plate 15 is movable normally to the plane of the paper.

The construction and mounting of the plates 14 and 15 will be described in detail hereinafter with reference to Figures 3 to 7.

With reference again to Figure 2, a shutter and filter assembly 17 is disposed between the plates and the projection lens system 13, for shutting off, or colouring the light leaving the projector. Two alternative forms of this assembly 17 will be described hereinafter with reference to Figures 8 and 9.

With reference to Figure 3, the point of

intersection 18 of the horizontal line 19 on plate 14, and the vertical line 20 on plate 15 defines the position of the corresponding light spot on the screen 2. The spot is therefore movable in any direction on the screen (and at an adjustable speed), by the controlled movement of the two plates 14 and 15. Plate 14 is driven by a stepper motor 21 arranged to rotate, via gear wheels 22 and 23, a threaded shaft 24 of a lead screw assembly 25. The assembly 25 also includes an internally threaded member 26, mounted on the plate 14 and cooperatively engaged with the shaft 24 so that the plate 14 is displaced vertically as the drive shaft of the motor 21 rotates. A similar drive assembly, comprising stepper motor 27, gear wheels 28 and 29 and lead screw assembly consisting of threaded shaft 30 and internally threaded member 31 is provided for displacing the plate 15 horizontally. Each plate is spring loaded to remove backlash in the screw. The stepper motors 21 and 27 are coupled to be actuated in accord with signals received over the corresponding output channel of the computer. An alternative drive assembly for the plates 14 and 15 is illustrated in Figure 4. Here, lead screw assemblies are driven through gear wheels from servo motors 32 and 33, controlled through closed loop systems including servo potentiometers 34 and 35 and servo amplifiers of high gain to ensure that small signal input changes are followed. These potentiometers' shafts are driven in accordance with the rotation of the drive shafts of the servo motors. Other drive mechanisms may be used, such as a rack and pinion.

Reference will now be made to Figures 5 to 7 which illustrate various features of a preferred embodiment of the invention. In this embodiment the concave mirror 8, lens 9 and heat filter 12 are provided as an optical unit which is readily obtainable commercially. The lamp 7 and lenses 10 and 11 are suitably mounted in association with this optical unit so that the optical configuration is as illustrated in Figure 2. A detailed description of the mounting arrangement for these elements is thought unnecessary here.

The plates 14 and 15 are mounted one on either side of a mounting plate 36 having a rectangular aperture 37 and arranged vertically normal to the axis 16 to locate the plates optically following the condenser lenses 10, 11. Transparent lines 19 and 20 are formed on mutually facing surfaces 38*a*, 39*a* of two planar glass slides 38 and 39 respectively, attached to the inner faces of the plates 14 and 15 within the area of the aperture 37. The plates 14 and 15 are formed with respectively horizontal and vertical elongate apertures 40, 41 over which the slides 38 and 39 are attached. These slides project inwardly of the depth of the aperture 37, so that the separation of the surfaces 38*a* and 39*a* is as small as possible, to ensure good focus for the projected spot. The opacity, apart from the transparent lines, of the slides 38 and 39 is provided by a coating on the surfaces 38*a* and 39*a* which coating may be an emulsion layer as on an exposed photographic plate, or alternatively a sputtered metallic layer. The metallic layer is preferred since, being highly reflective, it prevents over-heating of the slides.

The plates 14 and 15 are rectangular, and their parallel longer edges are bevelled to engage with low friction rollers 42 of, for instance, nylon. Three such rollers are rotatably mounted on each side of the mounting plate 36, two rollers engaging one edge and the third engaging the other edge of the respective plate. The rollers 42 each have a circular flange 43 which serves to space the plate from the surface of the mounting plate 36, and, integrally formed therewith a frustoconical portion 44 which engages the bevelled edge 14*a* or 15*a* of the plate.

The stepper motors 21 and 27 are both disposed on the side of the mounting plate 36 carrying the plate 15. Edge plates 45 and 46 are fixedly attached respectively to a vertical and the top edge of the mounting plate. The motors 27 and 21 are mounted, by means of spacers 47 on the edge plates 45 and 46 respectively, and the gear wheels 23 and 29 are located in cut out portions along the edges of the mounting plate. The internally threaded member 26 on plate 14 projects through a slot 48 in the mounting plate.

The spring loading of the plates to remove backlash is provided by coil springs 49, 50 wound on spools 51 and 52. These spools are rotatably mounted in further slots 53 and 54 in the mounting plate, and the free ends of the coil springs 49, 50 are fixedly attached to the plates 14, 15 respectively. In a particular embodiment the aperture defined by the intersection 18 was movable within a rectangular area 36 mm in width and 24 mm in height, and the maximum speed of the motors was such that the minimum traverse time of this aperture was about 40 seconds for full horizontal travel, and 15 seconds for full vertical travel.

Referring now to Figure 8, a shutter arrangement 17 is illustrated, in which a plurality, in this instance three blades are pivotally mounted on a support plate 55. Each blade is attached to the shaft 56 of a two position rotary actuator 57, which may, for example be a stepper motor or a rotary solenoid mounted on the opposite side of the support plate, which has a central aperture 58. The projection lens system is

mounted on the opposite side of the support plate in optical alignment with aperture 58. One of the blades 59 is a shutter, and when positioned over the aperture 58 prevents the projection of a light spot. The other two blades 60 constitute mounting elements for a pair of coloured filters, one green and one red, and are formed with circular apertures in, or over which the filters are fixed. By selectively positioning the blades 60 by operation of the respective two-position rotary actuators, the projected light spot may be coloured green or red. If no blade is positioned over the aperture 58, a white spot is projected. Operation of the motors 57 is again controlled by the computer.

Figure 9 illustrates an alternative arrangement in which a filter plate 61 is pivotally mounted on the support plate 55 and attached to the spindle of a three position rotary actuator 62 so as to be movable to any of three position. In one of these positions an aperture 63 in the filter plate 61 is positioned over the aperture 58 in the support plate, to allow a white spot to be projected. In the other positions either a green or a red filter 64 or 65 is positioned over the aperture 58. To block the light, a blade 66, and a two-position rotary actuator are provided as in the arrangement of Figure 8.

It will be readily understood that with the planar movement (as distinct from an angular movement) of the crossing point of the two lines 19 and 20 there is a linear relation between the movement of this point and the corresponding movement of the light spot on the flat screen. That is to say, if the crossing point is moving at a constant speed in a particular direction, the light spot on the screen moves in the same direction at a constant, but greater, speed. This is particularly advantageous, since in an arrangement such as that illustrated in Figure 1, where a plurality of projectors are employed, these may be disposed about the centre line A—A of the system, and a single zero correction made to each projector during setting up to bring the zero positions of their individual light spots into exact coincidence on the screen. This zero correction may be provided either by a small lateral movement of the projector lens, by an electrical zero setting in the servo drive amplifier used to drive the corresponding servo motor, or by a zero setting command in the computer. Such corrections may be used together, the lens adjustment giving an approximate correction, and the electrical or computer adjustment giving a fine correction.

The rotary actuators operating the shutter arrangement 17 are controlled by the computer so that the blades/shutter plate may be operated in accordance with a predetermined sequence, to simulate any of a number of different types of navigation light, such as a flashing white light, or a constant red light etc., the sequence of thee flashing being determined by the length of, and separation between, voltage pulses applied to the rotary actuators which may be stepper motors.

It will be appreciated that when the apparatus is in use as a marine navigational simulator, lights at or about the horizontal mid-line of the screen will represent navigational lights on the horizon, i.e. distant, while lights nearer to the bottom of the screen will represent closer navigational lights. It is desirable, therefore that the light spot increases in apparent brightness when it moves downward across the screen, while remaining substantially of the same brightness when it moves only horizontally. A lenticular projection screen, when arranged with its lines running vertically provides a reflectance polar diagram which is such that the required variation of apparent brightness can be obtained without the use of complex apparatus. To achieve this it is arranged that the projector-screen-eye path is on the polar diagram maximum when the light spot is at the bottom of the screen, and is off the maximum when the light spot is at the middle of the screen. Alternatively, the change in brightness may be brought about by varying the lens aperture or projector lamp brightness by command from the computer.

WHAT WE CLAIM IS:—

1. A projector for projecting a movable spot of light onto a screen comprising an optical system including means defining an aperture which is controllably displaceable in a predetermined aperture plane, a light source for illuminating the aperture and means for focusing an image of the illuminated aperture onto the screen to form a spot of light thereon, said means defining the displaceable aperture comprising a first movable element defining a straight slot which is transparent to light from said light source, a second movable element which defines a straight slot which is also transparent to light from said light source and which crosses the slot of the first element at a crossing point defining said aperture, and means for independently moving said first and second elements to displace the aperture in said aperture plane.

2. A projector according to claim 1 wherein the said slots extend in orthogonal directions.

3. A projector according to claim 1 or claim 2 wherein said first and second elements are mounted for movement in orthogonal directions.

4. A projector according to claim 3 and

claim 2 wherein the first and second elements are each mounted for movement in a direction normal to the direction of extension of the respective slot.

5. A projector according to any preceding claim wherein the first and second elements comprise a pair of plates, each of which is opaque apart from a fine straight transparent line which constitutes the respective straight slot, said plates being mounted adjacent and parallel to one another.

6. A projector according to claim 5 wherein each plate is mounted for linear movement in its own plane.

7. A projector according to claim 5 or claim 6 wherein each plate is formed with an elongate aperture and includes a planar slide disposed over said elongate aperture on one side of the plate, said fine transparent line being formed in said slide which is otherwise opaque.

8. A projector according to claim 7 wherein said plates are mounted with their respective slides parallel to and adjacent each other.

9. A projector according to claim 7 or claim 8 wherein, in respect of each plate, the fine transparent line is formed in an otherwise opaque coating on a surface of the respective slide.

10. A projector according to claim 8 and claim 9 wherein said opaque coatings are provided on mutually facing surfaces of said slides.

11. A projector according to any preceding claim wherein the means for moving the first and second elements comprise, in respect of each of said elements, a drive assembly comprising a motor having a rotatable drive shaft coupled to move the respective element through a lead screw drive assembly.

12. A projector according to claim 11 wherein said motor is a stepper motor.

13. A projector according to claim 11 wherein said motor is a servo motor and said drive assembly also includes a servo potentiometer having a rotatable shaft coupled for rotation in accord with the rotation of the drive shaft of the motor.

14. A projector according to any of claims 11 to 13 wherein each said element is spring biased to overcome backlash in the lead screw assembly.

15. A projector according to any preceeding claim including a displaceable shutter for interrupting the optical path of light from the aperture.

16. A projector according to claim 15 wherein the shutter comprises a blade mounted on the shaft of a rotary actuator which is selectively operable to pivot the blade into and away from the said optical path.

17. A projector according to any preceding claim including a coloured filter displaceably mounted to be interposed in the optical path of light from the aperture.

18. A projector according to claim 17 wherein the filter is carried by a mounting element mounted on the shaft of a rotary actuator which is selectively operable to move the filter into and away from the said optical path.

19. A projector according to claim 18, and including a plurality of said filters, each of different colour, and each carried by a respective mounting element mounted on the shaft of a respective stepper motor.

20. A projector according to claim 18 and including a plurality of said filters, each of different colour and each carried on said mounting element.

21. A projector for projecting a moveable spot of light onto a screen, substantially as herein before described with reference to and as shown in Figures 2 to 9 of the accompanying drawings.

22. A simulating system including a screen and a plurality of projectors according to any preceding claim arranged to project light spots onto the screen, the first and second elements of the projectors being displaceable to produce a changing pattern of lights on the screen.

BOULT, WADE & TENNANT,
Chartered Patent Agents,
34 Cursitor Street,
London, EC4A 1PQ.

Printed for Her Majesty's Stationery Office by Burgess & Son (Abingdon), Ltd.—1978.
Published at The Patent Office, 25 Southampton Buildings, London, WC2A 1AY,
from which copies may be obtained.

1536278 COMPLETE SPECIFICATION
3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 1

FIG.1

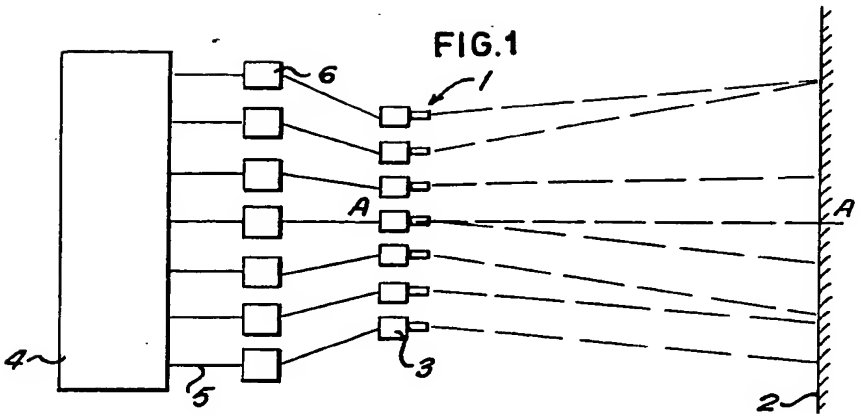



FIG.2

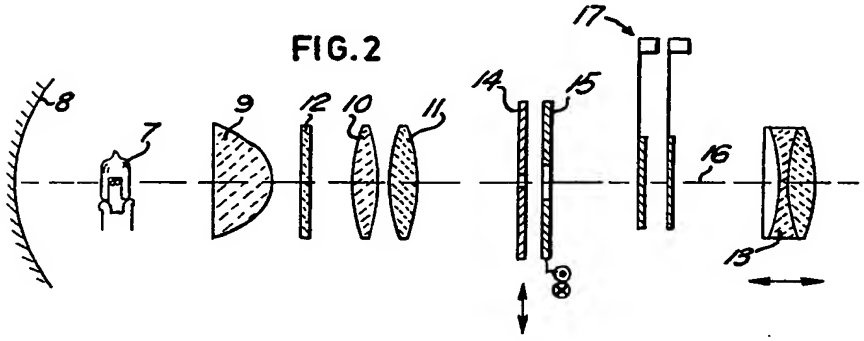



FIG.8

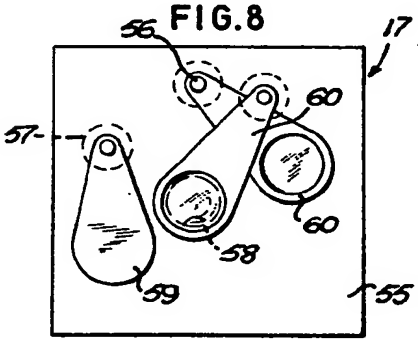



FIG.9

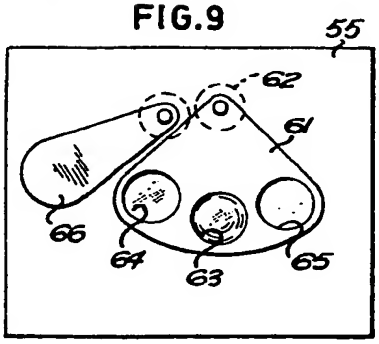


FIG. 3

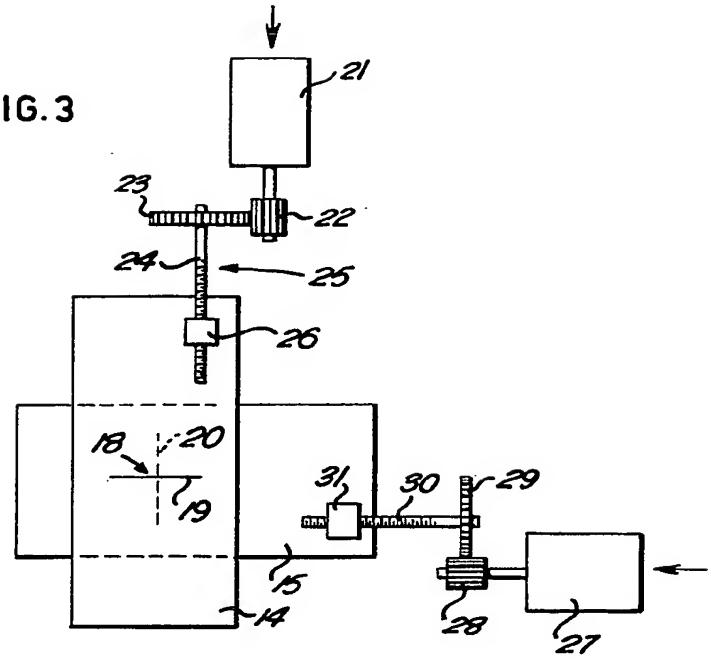
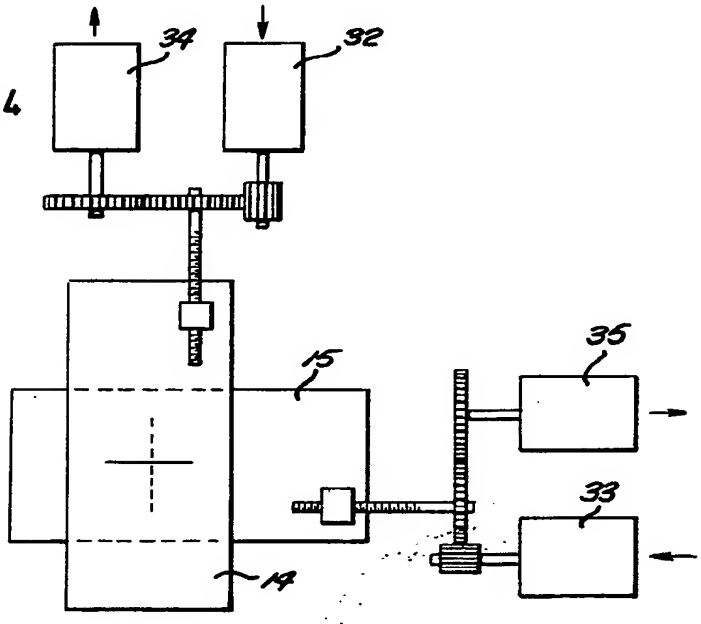



FIG. 4



1536278 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 3

FIG.6

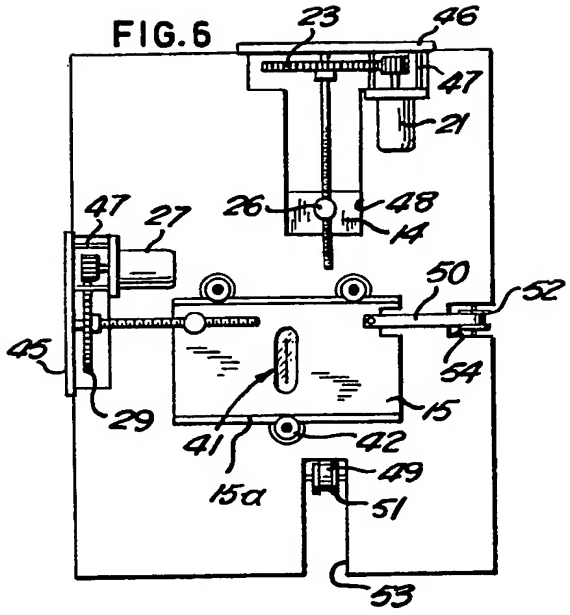



FIG.5

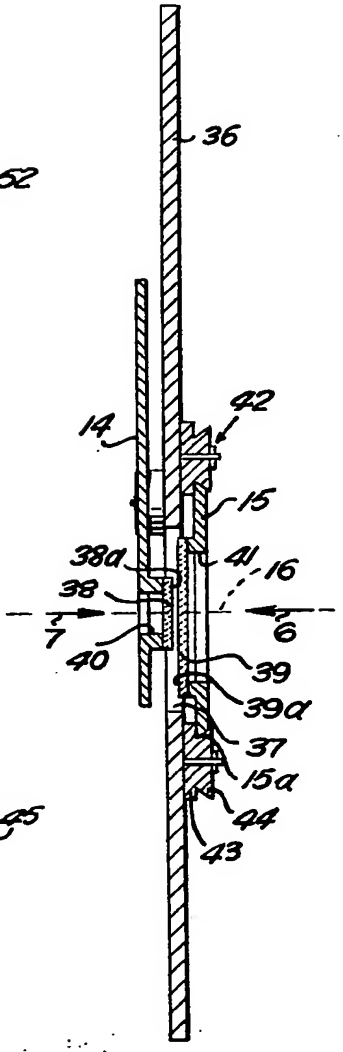



FIG.7